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## IoT-Based Smart Environment Monitoring System for Air Pollutant Detection in Kuantan, Pahang, Malaysia

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# IoT-Based Smart Environment Monitoring System for Air Pollutant Detection in Kuantan, Pahang, Malaysia

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**Abstract.** Air pollution is one of the pollutions that release harmful chemicals and if not controlled, it will affect the human respiratory system. Currently, there are two Air Pollution Monitoring system located in Kuantan district to record the pollution's reading once it detects the air pollutant however, the origin of the pollution cannot be detected by the system. As a solution, a Smart Environment Monitoring System for Air Pollution Using Internet of Things (IoTs) is developed to overcome the weaknesses. This project involved both hardware and software developments, in which hardware development includes the Arduino Uno, Carbon Monoxide (MQ 7), smoke/gas (MQ 135) sensors, a buzzer and LCD display. This system is design so that the current reading can be viewed by admin in a real-time value. Besides, they can also view the data for every 8 hours. These data can be printed in PDF format. In addition, when the reading reached unhealthy value, it will warn the community via its alarm system embedded in this system. However, this system is subject to limitation especially on data delays from sensors to database. As only one existing monitoring system that located at Beserah, thus this new feature will add a sub-sensor that located at the designated area which potentially expose to the air pollution.

**Keywords**—Internet of Things, Air Pollution Monitoring, Carbon Monoxide, Sensors, GSM Module, Arduino

## 1. Introduction

The key measures to be closely observed in real time for today's urban environment is the quality of air. This is because, it has a predominant impact on human health, safety and comfort. Air pollution can cause preterm births in newborns and Alzheimer's in the elderly. Air pollution is the release of harmful chemicals into the atmosphere causes discomfort to humans as well as cause damage to other living



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organisms such as food crops or the natural environment [1-2]. One of the main causes for air pollution in Malaysia is the emission of the combustion of fossil fuels vehicles. However, bauxite mining has been growing concern in Malaysia nowadays especially in the parts of state of Pahang in which, it covered with layers of red dust. Additionally, this bauxite sediment also pollutes the sea along the coast of Kuantan, which is one of the tourist attraction beaches near Teluk Cempedak. Practically, the existing air pollutant detection system in Malaysia are not capable to detect the source of the pollutants. It can only detect the minimum and maximum value of the air quality within its zone only. Therefore, to overcome this problem, the existing systems need to be upgrade and it should be re-locating at the potential areas to enhance its functionality.

There are some issues from the existing system that currently uses by the Department of Environment (DoE). First, the current systems use too many sensors which is not significantly used in the current environment. Second, there are only two air pollution monitoring stations in Kuantan which is at Beserah and Indera Mahkota. This is due to the high cost needed to build and develop the device. Third, the location of the current system is not too specific. The two main stations that locate in SMK Indera Mahkota and SMK Pelabuhan is the insignificant place for activities that give an impact to air pollution. There are few existing systems that had been developed previously which is Air Pollution Index (API) Real Time Monitoring System [3], Arduino-Based Air Quality Monitoring [4] and IoT Based Air Pollution Monitoring System Using Arduino [5]. Norhafizah et.al [3] developed the API Real-Time Monitoring System in purposed to detect and monitor the dust in the industrial area at Parit Raja, Johor. The authors had integrated the dust sensor and LCD shield with Arduino Uno. This system only allowed data transmitted into the laptop via USB cable and data collected were viewed using Microsoft Excel.

On the other hand, Haro Prasaath [4] had developed an Arduino-based Air Quality Monitoring by using MQ 135 sensor which is sensitive to the natural gas and Liquefied Petroleum Gas (LPG). This device embeds the MQ 135 sensors, LCD Screen and Wi-Fi Modules with an Arduino Uno Microprocessor. All data is stored at <http://thingspeak.com> in which, ThingSpeak is a tool that let the user to store all sensor data at cloud. Moreover, this device only used one (1) gas sensor which is the MQ 135 sensor. This system integrates Wi-Fi Modules as their network connector [9-12]. However, these devices need to be installed near the Wi-Fi hotspot. In addition, this system only displays all the data in the ThingSpeak website.

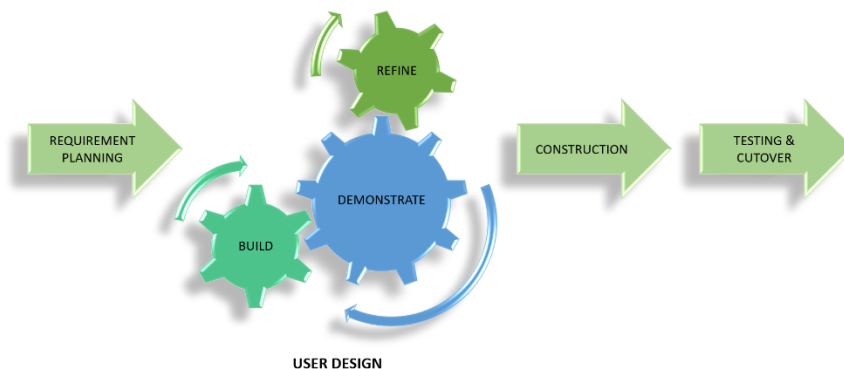
IoT-Based Air Pollution Monitoring System using Arduino developed by Darshan Mirajkar [5] used only smoke sensor and specially design to detect and alerted any air pollution causing from open burning. Authors used Wi-Fi Module, Smoke Sensor, LCD Display and buzzer which integrated into Arduino Uno as their microprocessor. This system allowed the data transmitted from sensor to the local database by Wi-Fi Module and the data will be shows in the monitoring page. For outdoor air pollution monitoring, instead being the low-cost network module, Wi-Fi Module is not suitable to be used. Besides, local database like XAMPP is not suitable for this device since local database can only connect with Arduino for Local Area Network (LAN). This device development did not include any function of log in page for admin and the system can't generate any report from the data.

The main objective of this study is to develop a low-cost smart environment monitoring system for air pollution using Internet of Things (IoT). This report is organized into four (4) parts. Section II briefly describe the methodology used in this work, meanwhile Section III presents the detailed explanation of its results and discussion. At the end of this report, the development of this system is being concluded.

## 2. Methodology

This proposed system was developed based on Rapid Application Development (RAD) model. RAD is a combination model of different organized methods with prototyping and joint application development procedures to speed advancement of the system [6]. It aims to build application faster using an iterative

development process as shown in Figure 1. Proponents of RAD claim that it increases productivity, reduces delivery time and gains high usage because of the extent of user involvement in the development [7].



**Figure 1.** RAD Methodology Phase

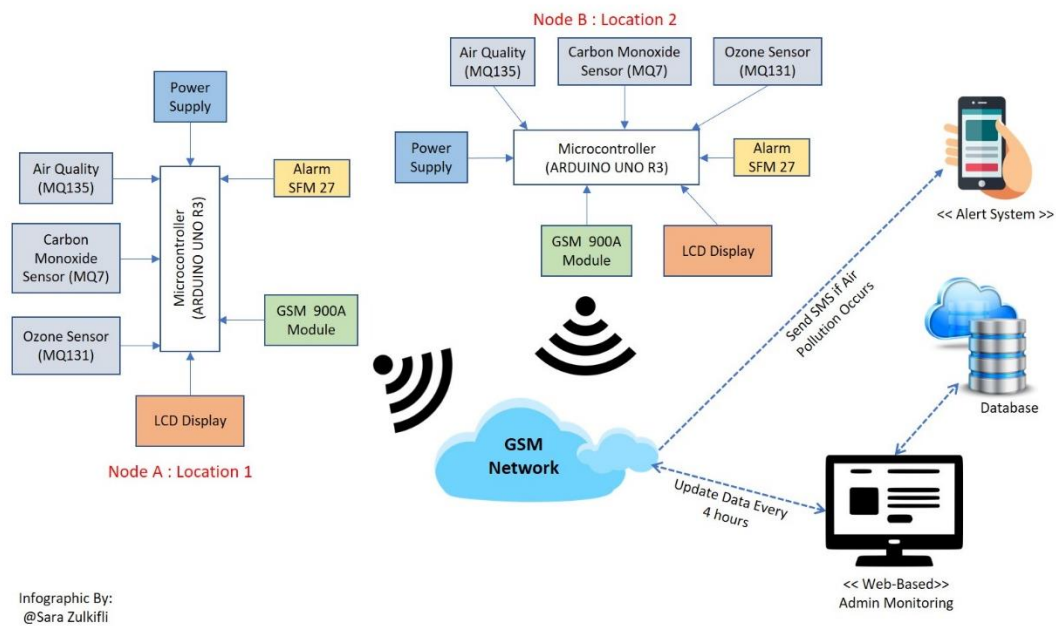
### 2.1. Requirement Planning

It is important to determine the needs of the study before doing the system. These needs include the establishment of the problem statement, objectives, data and functional requirements and identification of hardware and software used in the implementation. Figure 2 shows the general architecture of this proposed system in which two nodes will be implemented in two different location given as Node A and Node B.

**2.1.1. Data Requirement.** There are two sensors attached to the Arduino Uno R3, which are the air quality sensor MQ-135 and carbon monoxide (CO) sensor MQ-7. These sensors provide the input for the proposed system. The MQ-135 sensor is used widely as a gas sensor for air quality. This sensor is used to detect or measure the air quality which consist of chemical substances such as Ammonia (NH<sub>3</sub>), Nitrogen Oxide (NO<sub>x</sub>), Alcohol, Benzene, Smoke and Carbon Dioxide (CO<sub>2</sub>). Whereas, the MQ-7 sensor module allows for the sensing of CO concentration in the air. It can detect the CO gas concentration from anywhere between 20 and 2000ppm. The output of the system can be seen through android mobile phone, online data display and storage as well as buzzer for red alert notification.

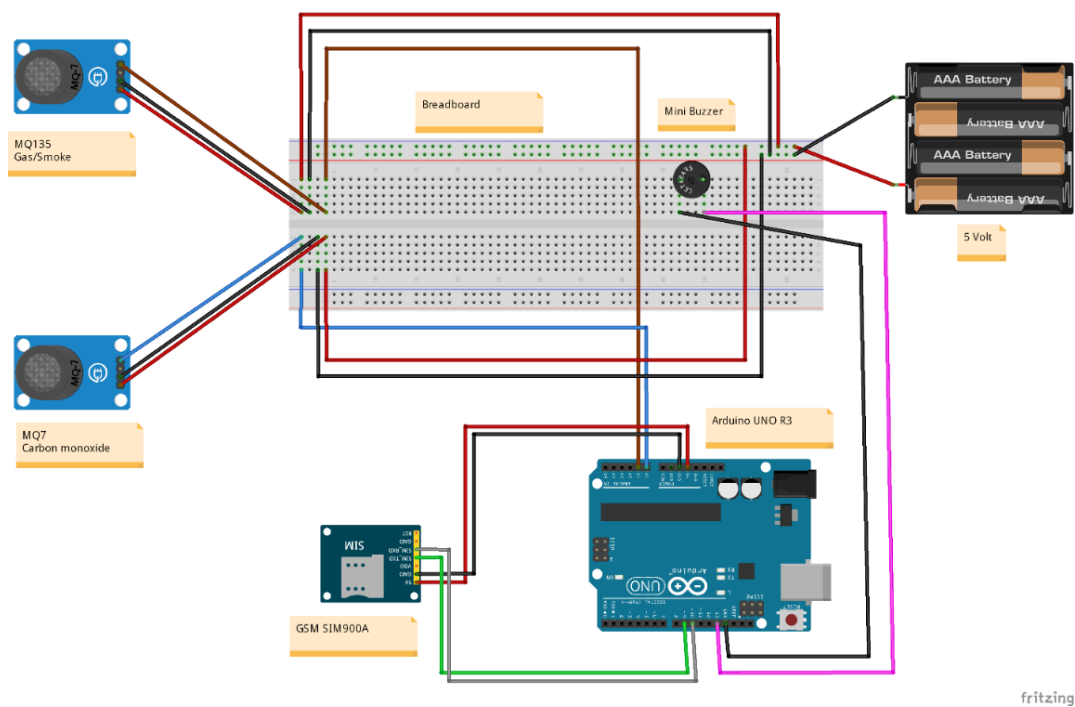
**2.1.2. Software Requirement.** C Programming language is used as the main programming language for the code development of the system. It is used to program the Arduino Uno by using Arduino IDE as its framework. Besides, several modules were also integrated with the system to realize the system's functionalities. On the other side, sublime is using to code the website development with Hypertext Preprocessor (PHP), Hypertext Markup Language (HTML) and CSS JavaScript as its main language. This website development is incorporate with MySQL database which allow the connectivity between GSM Module and the database to ensure all data from the sensor can be transmitted and stored to the database.

**2.1.3. Hardware Requirement.** The core development of this IoT device consist of an Arduino Uno R3, which is a microcontroller board with 20 digital input/output pins that work as a processing device for this system. Due to its flexibility and ability to respond to sensors and inputs, this Arduino can interact with a large array of outputs. Figure 3 shows the circuit diagram used for each node in the proposed system. For the prototype of this proposed system, 4 AAA battery were used as the power supply.



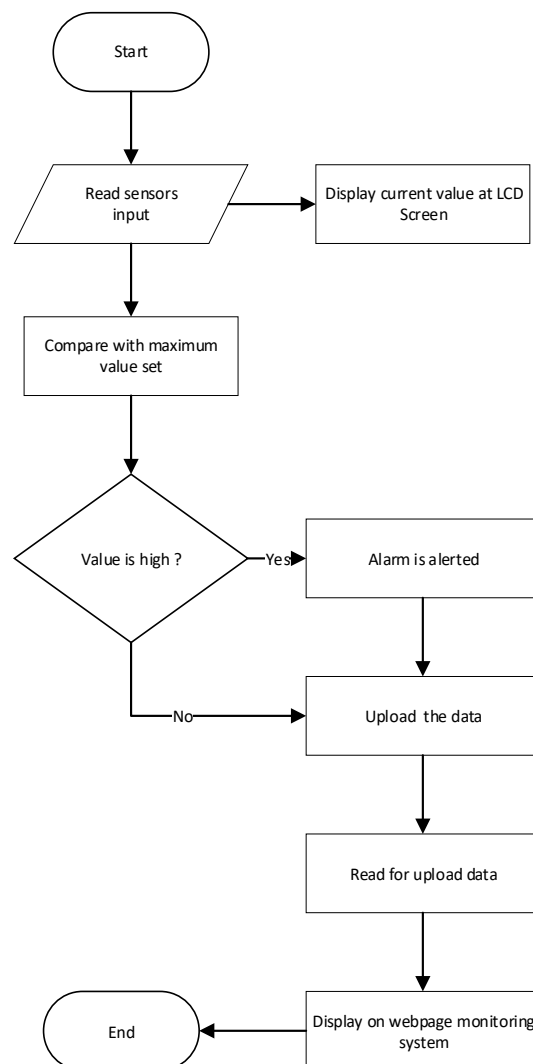
**Figure 2.** General Architecture of Proposed System

The important key of this IoT device is the sensor. A sensor is a device that detects or measures a physical environment and respond to it. The output of these sensors is sent directly to online MySQL database through GSM SIM 900A. GSM SIM 900A is a GSM Module that work to establish communication between a computer and a GSM-GPRS system which work together with a buzzer for indicator as an additional hardware to this IoT device [14].



**Figure 3.** Circuit Diagram of the IoT Devices

**2.2. User Design.** User design is created based on requirements collected in the early phase. In this phase, model and prototype that represent all system processes including inputs and outputs are developed. A detailed user design includes how the system's flow, from beginning until the end, how many users include and how the systems architecture looks like. This phase enables users to see to general flow of the system, understand the process flow and modify the working model of the system that meets their needs. Figure 2 demonstrate the general architecture of the proposed system which integrates the sensors, mini buzzer, GSM Module and cloud storage with the Arduino Uno R3. The outcomes from this phase will deliver to the next phase which is the construction phase.



**Figure 4.** Flow Chart of the Proposed System

**2.3 Construction.** In construction phase, the detailed gritty diagram of the system models is completed with the system realization, framework and imperative documentation designed work for the proposed application. During the period time of construction, three (3) phases should be done which is the establishment of hardware and software. It is important to configure all hardware integrated in the system and program the Arduino Uno board based on the proposed design to ensure the system works properly. In addition, the GPRS GSM Module connection should be configured properly in order to enable the storage of data acquisition into the cloud and being display in the website and android applications. The last part in construction phase was an android notification to the community to alert

them about the pollution. The process cycle between the user design phase and construction until final prototype is created. Figure 4 shows the flow of the proposed system.

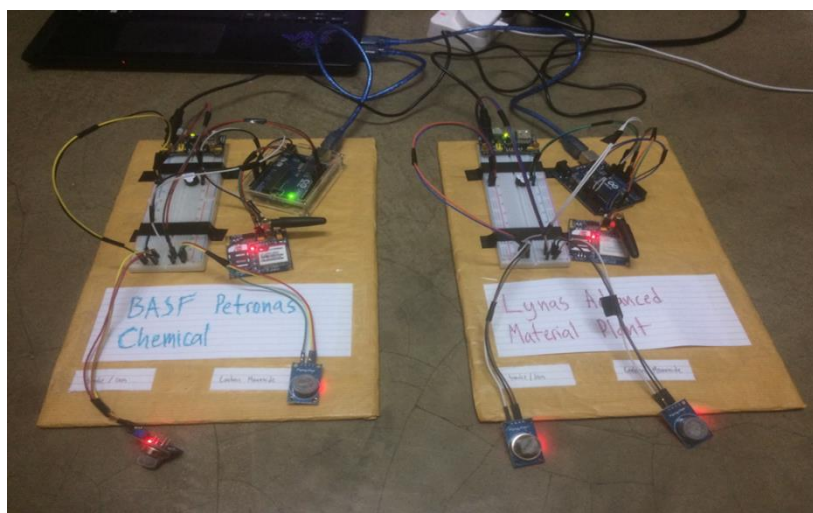
**2.4 Testing and Cutover.** To acquire a complete system and test the system functionalities, both software and hardware were combined in this system. In this phase, the hardware prototype and the web-site design in its own server as well as the android applications were tested together to ensure all sensors, alert notification and buzzer work properly based on the setup function. In this proposed system, the level of air pollution was set in the construction step accordingly as indicated in Table 1. In this system, when the sensor detected the level of hazardous pollution, mini buzzer and notification will alert from the android application known as CleanKuantan2.

**Table 1.** Pin to Pin Details from Arduino to Hardware

Arduino	Sensors/Hardware	
A0	MQ 7	A0
A1	MQ 135	A0
9	GSM	5Tx
10		5Rx
13	Buzzer	Positive

### 3. Result and Discussion

In this study, three (3) experiments were conducted which is the connectivity test of sensors with Arduino Uno R3, network connection of GPRS GSM SIM900A with cloud storage and web-site design, generation of PDF report from web site and integration test of cloud storage between web sites and android application.



**Figure 5.** Connectivity of Sensors and the Arduino Uno R3 and GSM Module

In the first experiment, the connectivity of MQ-135 and MQ-7 sensors with the Arduino Uno R3 and GSM Module are shown in Figure 5 were tested. Two nodes for two different station were developed to test the concurrent data transmitted in the same time into the cloud storage. The connections of the sensors to the Arduino Uno R3 board are shown in Table 1, where MQ 135 is connected to pin A1 in Arduino and MQ 7 to pin A0. Both Transmitted, Tx and Receiver, Rx pins for GSM SIM900A were

connected to digital pin 9 and 10, respectively. Initially, Arduino IDE was used to setup the connection of all sensors and buzzer to the microprocessor Arduino Uno R3 as shows in Figure 6. Then, the Arduino Uno R3 was connected to the port to compile the programming into the Arduino. This is shows in Figure 7. It is important to check either the port connected is right or not. To ensure the right programming being compile into the right microcontroller. Once the compiler successfully done, system will show a notification as depicted in Figure 8.

Figure 9 display the code used to establish the connection in GSM SIM900A to the cloud network. This establishment allowed data to be transmitted to the cloud database. And from here, data will be retrieved and display in web-based monitoring system and android application. Figure 10 shows the serial monitor interface which is used to display the connection between Arduino Uno and GSM SIM900A Module.

Figure 12 shows the PDF report which can be downloaded by the DOE as reference report for further analysis especially when the device detected a pollution at the designated area. On the other hand, community which equipped with an android application known as CleanKuantan2 also get an alert notification regarding the pollution area through the apps. This alert notification helps the community to take early precautions.

**Table 2. Air Quality Index (API) Level**

API Reading	Status	Color
0 - 50	Good	Blue
51 - 100	Moderate	Green
101 - 200	Unhealthy	Yellow
201 - 300	Very Unhealthy	Orange
> 300	Dangerous	Red

```
// Carbon Monoxide
lcd.begin(16, 2);
lcd.print("Carbon Monoxide");
finalVal=(float)val/1024*5.0;
lcd.setCursor(0, 2);
lcd.print(finalVal, 1); //Print the value to serial port
lcd.println(" PPM");
delay(3000);

//Smoke
lcd.begin(16, 2);
lcd.print("Smoke");
finalSV=(float)sensorValue/1024;
lcd.setCursor(0, 1);
lcd.print(finalSV, 2);
lcd.println(" PPM");
delay(3000);

if (finalVal > 100 || finalSV > 100)
{
  alertBuzzer();
}
else
{
  }
}
```

**Figure 6. Code Programming for sensors, buzzer and LCD screen**



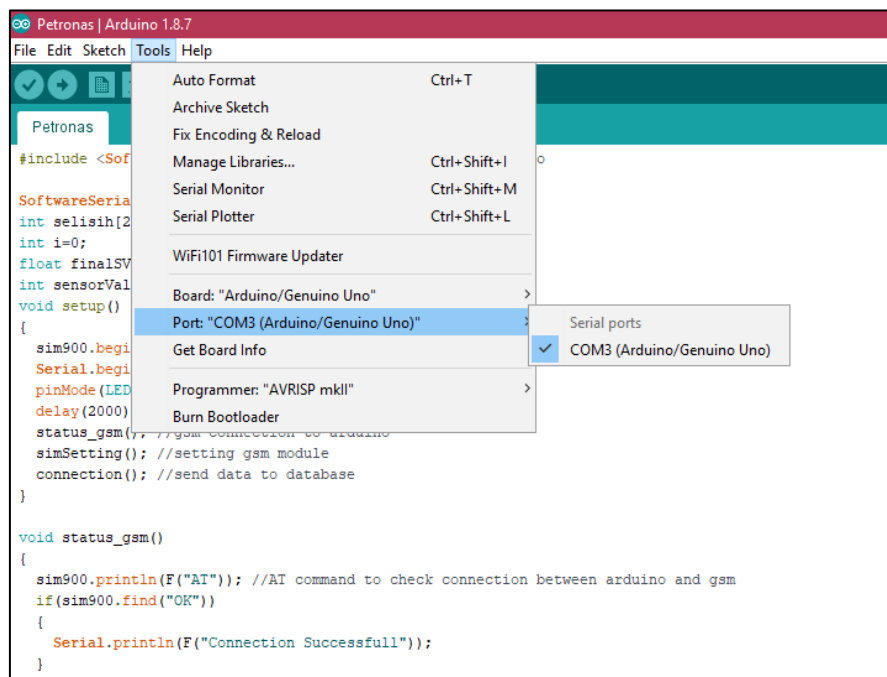


Figure 7. Select Port for Arduino Uno Compiler

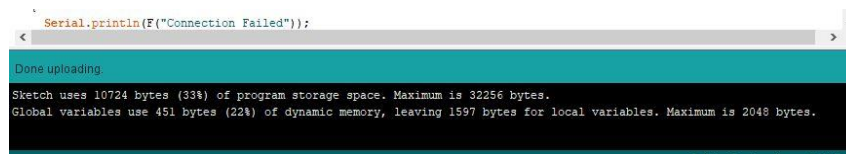


Figure 8. Arduino IDE notify the compiling process

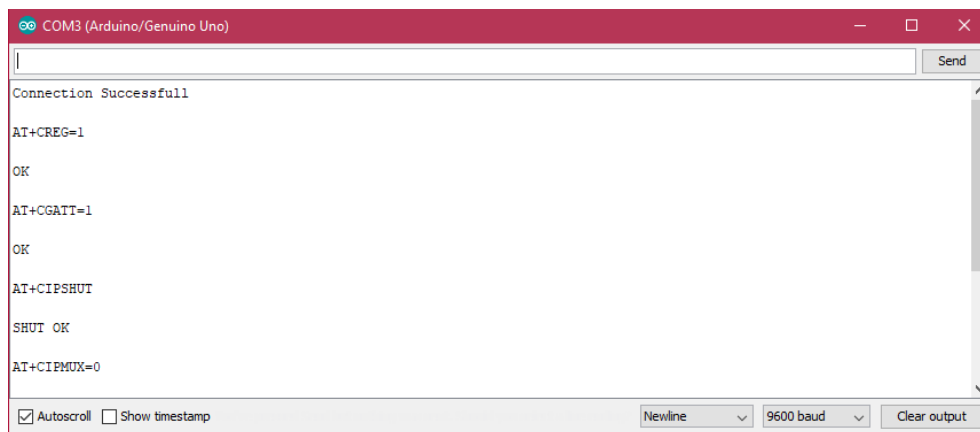
```

void koneksi()
{
  sim900.println(F("AT+CIPSTART=\"TCP\", \"lienawan.xyz\", 80)); //memulai koneksi dengan server
  delay(1000);
  Serial.println(sim900.readString());
  if(sim900.find("OK"))
  {
    Serial.println(F("proses data"));
  }
  String link = "GET /input.php?co="+String(finalVal)+"&smoke="+String(finalSV)+" HTTP/1.1\r\nHost: lienawan.xyz\r\n\r\n";

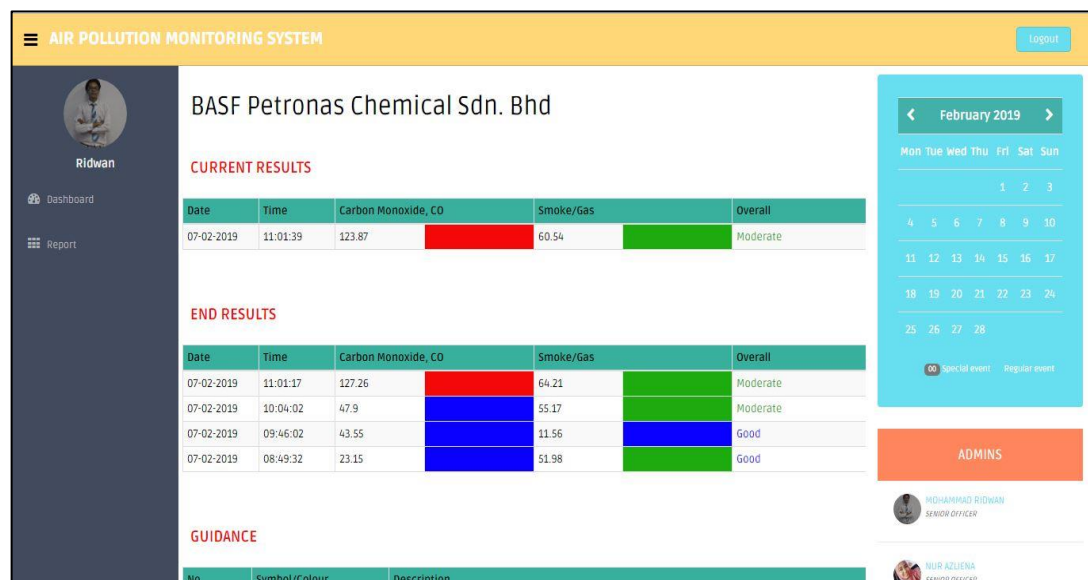
  sim900.print(F("AT+CIPSEND=")); //mengirim request data
  sim900.println(link.length()); //mengirim panjang tautan request data
  delay(500);
  if(sim900.find(">"))
  {
    sim900.print(link); //mengirim tautan ke server
    if(sim900.find("SEND OK"))
    {
      delay(100);
      while (sim900.available())
      {
        Serial.println(sim900.readString()); //feedback data (sesuai dengan keluaran di browser)
      }
      sim900.println(F("AT+CIPCLOSE")); //stop koneksi
    }
    else
    {

```

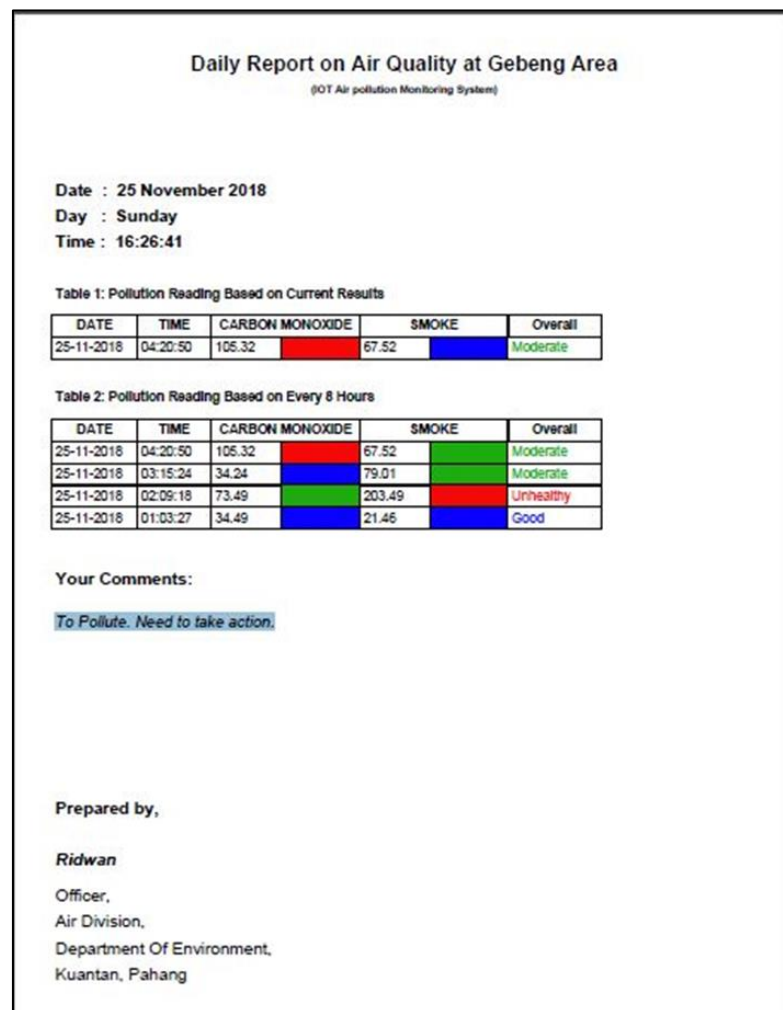
Figure 9. Code for Network Connection in GSM SIM900A



**Figure 10.** Serial Monitor Interface shows the connection between Arduino Uno and GSM SIM900A



**Figure 11.** Web-Based Cloud Storage



**Figure 12.** PDF Report generated by DOE when the device detected pollution at the designated area

#### 4. Conclusion

In this paper, it has shown the development of the proposed solution for air pollution monitoring system which integrates GSM Modules, air quality sensor and Arduino Uno to form the Internet of Things (IoT)-based system. This system is expected to improve the current systems that had been used by the Department of Environment (DoE), Kuantan, Pahang. This monitoring system exhibit several strengths in which it can help DoE to monitor the air quality from area that exposed to get the pollution especially in the exact industrial area.

This monitoring system also providing a real-time web-based cloud application that allow the DoE to monitor, update and display the air quality data on each industrial site. If unhealthy air quality is detected in certain industrial area, it will alert both industrial and DoE through alert notification indicated using buzzer. Compared to existing system developed by N.A Zakaria [8], this device transmit data to the cloud storage using GSM Sim900. Instead of using thinkspeak.com as the web-based cloud storage, we develop our own website which can be used by DOE to monitor all stations. This smart monitoring system is easy to install and maintain as it requires very low technical skills and knowledge for device handling. However, this monitoring device still have small problem in providing a real-time to the web-based and Arduino applications [13-14]. Thus, further research in this domain should be explored to enhance the quality of data transmitted and to ensure that data display on the web-based and android application is in a real time.

## Acknowledgement

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## References

- [1] A. Hasfazilah, Y. Ahmad Shukri and R. Nor Azam, "PM<sub>10</sub> Analysis for Three Industrialized Areas using Extreme Value," *Sains Malaysiana* vol. 44 (2), 2015. pp. 175 -185.
- [2] Mateen, F.J., and Brook R.D, "Air Pollution as an emerging global risk factor for Stroke," *JAMA*, 305 (12), 2011. pp.1240-1241
- [3] Ruslan,N et al., "Air Pollution Index (API) Real Time Monitoring System. University Tun Hussein Onn. Thesis. 2015.
- [4] Prasaath, H., "Arduino Based Air Quality Monitoring IOT Project," *Engineer Garage*. 2017
- [5] Mirajkar, D. "IoT based Air Pollution Monitoring System Using Arduino". 2015.
- [6] Idesis,S. "What is Rapid Application Development?". 2017
- [7] Coleman,G and Verbruggen,R. "A quality software process for rapid application development,". 1998
- [8] N.A Zakaria, Z.Z.Abidin, N.Harun et. al, "Wireless Internet of Things-Based Air Quality Device for Smart Pollution Monitoring", *International Journal of Advanced Computer Science and Applications*, Vol. 9, No.11, 2018, pp.65-69.
- [9] AA Shahidan, N Faisal, Nor Syahidatul N Ismail, Farizah Yunus, Sharifah HS Ariffin., "Data recovery in wireless sensor networks using network coding," *Jurnal Teknologi*, vol.73 (3), 2015.
- [10] Farizah Yunus, Nor Syahidatul N Ismail, Sharifah HS Ariffin, SK Syed Yusof, "A rate Control Model of MPEG-4 Encoder for Video Transmission over Wireless Sensor Network," *International Journal of Communication Networks and Information Security*, vol 11(1), 2019. Pp.42-51.
- [11] NSA Zulkifli, FK Che Harun, NS Azahar, "Centralized heart rate monitoring telemetry system using ZigBee Wireless Sensor Network," *Proceeding of 2012 IEEE-EMBS International Conference on Biomedical and Health Informatics*, 2012, pp. 265-268.
- [12] NSA Zulkifli, FK Che Harun, NS Azahar,"XBee Wireless Sensor Networks for Heart Rate Monitoring in Sport Training," 2012 *International Conference on Biomedical Engineering (ICoBE)*, IEEE, 2012, pp.441-444.
- [13] D. Swati, B.M. Rajasekhara, H.G Amir et. al., "Internet of Things Mobile-Air Pollution Monitoring System (IoT-Mobair)," *IEEE Internet of Things Journal*, vol 6 (3), June 2019, pp.5577-5584.
- [14] M.M. Shahkhir, A.B. Rohani, W.D. Wan Isni, "Indoor Localization Estimation Techniques in Wireless Sensor Network," 2018 *IEEE International Conference on Automatic Control and Intelligent Systems*, 2018, pp. 148-154.